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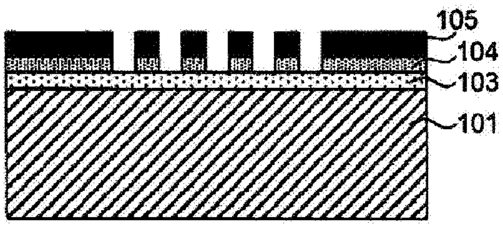
(54) **Lithography system, sensor, sensor surface element and method of manufacture.**

(57) A charged particle system for transferring a pattern to a surface comprising a sensor used for determining one or more characteristics of one or more charged particle beamlets, comprisïng a surface element for exposure by one or a plurality of charged particles beamlets, the sensor surface element comprising a converter element for receiving charged particles and generating photons, the converter element comprising a surface for receiving the charged particle beamlets, the surface being provided with one or more cells for evaluating individual beamlets, each cell comprising a predetermined blocking pattern of charged particle blocking structures forming knife edges at transitions between blocking and non-blocking regions along a predetermined scan trajectory over said surface, wherein said converter surface is covered by a light stopping metal layer permeable to said beamlets, and wherein the sensor between said light stopping layer and said blocking structures comprises a further electrically conductive layer.



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Dit octrooi is verleend ongeacht het bijgevoegde resultaat van het onderzoek naar de stand van de techniek en schriftelijke opinie. Het octrooischrift komt overeen met de oorspronkelijk ingediende stukken.

LITHOGRAPHY SYSTEM, SENSOR, SENSOR SURFACE ELEMENT AND METHOD OF MANUFACTURE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a charged particle lithography system, in particular to a maskless charged particle system, to a sensor therefore, in particular for determining charged particle beam properties, to a sensor surface element therefore, as well as to a method of manufacturing the same.

2. Description of the Related Art

Charged-particle beamlet lithography systems make use of a plurality of charged particle beamlets to transfer a pattern onto the surface of a target. The beamlets may write the pattern by being scanned over the target surface while their trajectory may be controllably blocked so as to create a beamlet that can be turned on or off. Blocking may be established by electrostatic deflection of beamlets on a blocking surface. Additionally, or alternatively, the size and shape of the beamlets may be adapted along the trajectory. Deflection, shaping and/or size adaptation may be executed by one or more electron optical components like for example an aperture array, an array of electrostatic deflectors and/or beamlet blankers.

In order to transfer a pattern onto the target surface, the controllable blocking of beamlets in combination with their movement over the target surface is performed in accordance with modulation information. An example of a multiple charged-particle beamlet lithography system is described in U.S. patent no. 6,958,804, which disclosure is herewith incorporated by reference in its entirety.

Such lithography systems can have very large numbers of beamlets, i.e. in the order of 10,000 or higher, for example 13,000. Future designs even envisage numbers in the order of 1,000,000 beamlets. It is a general aim for current electron beam lithography systems to be able to pattern a target surface in high-resolution, with some applications being capable of imaging patterns with a critical dimension of well below 100 nm feature sizes.

For such multiple beamlet, high-resolution lithography systems to be commercially viable it is important that the position of each one of the charged particle beamlets is precisely known and controlled. Additionally, knowledge and control of spot size and shape and intensity of the beamlets at the target surface are also of importance. Due to various

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circumstances, such as manufacturing tolerances and thermal drift, such beamlet characteristics may however deviate from their expected and desired characteristics, which may render these deviating beamlets invalid for accurate patterning.

Such deviations may include, among other things, a deviation in position, a deviation in spot size as exposed on the target surface and/or a deviation in beamlet intensity. Deviating beamlets may severely affect the quality of the pattern to be written. It is therefore desirable to detect these deviations so that corrective measures may be taken.

In conventional lithography systems, the position of each beamlet is determined by frequent measurement of the beamlet position. With knowledge of the beamlet position the beamlet can be shifted to the correct position. For accurate writing it is beneficial to determine the beamlet position within a distance in the order of a few nanometres.

Known beamlet position calibration methods generally comprise at least three steps: a measuring step in which the position of the beamlet is measured, a calculating step in which the measured position of the beamlet is compared to the desired expected position of that beamlet, and a compensation step in which the difference between the measured position and the desired position is compensated for. Compensation may be performed either in the software or in the hardware of the lithography system.

In advanced charged particle beamlet lithography systems, besides position control, beamlet spot size control may be of equal importance. Desired specifications for spot size measurements include determination of beamlet spot sizes in the range of 30 nm to 150 nm; accuracy of spot size measurements with 3 sigma value smaller than 5 nm; and a reproducibility of such spot size measurements within a single sensor with 3 sigma value smaller than 5 nm.

It is desirable to determine characteristics like beamlet position and/or beamlet spot size during operation of a lithography system to allow for early position and/or spot size calibration to improve the target surface patterning accuracy. In order to limit negative effects on throughput, i.e. the number of target surfaces that can be patterned within a predetermined period of time, it is desirable that the method of measuring the characteristics of the charged particle beamlets can be carried out within a limited period of time without sacrificing accuracy.

A sensor for measuring properties of a large number of charged-particle beamlets, in particular for charged particle beamlets used in a lithography system, is described in US published patent application 2007/057204 assigned to the present applicant, the content of which is herewith incorporated by reference in its entirety.

US 2007/057204 describes a sensor and method in which charged-particle beamlets are converted into light beams, using a converter element such as a fluorescent screen or a doped YAG material. Subsequently, the light beams are detected by an array of light sensitive detectors such as diodes, CCD or CMOS devices. A relatively fast measurement can be achieved by reading out a large number of light sensitive detectors in a single operation. Additionally the sensor structure, in particular the array of light detectors, enables a very small pitch of a multiplicity of beams to be measured without the necessity of unduly large structural measures in the region of the stage part of a lithography system.

However, in view of the continuously increasing demands of the industry regarding small dimensions without loss of throughput, there remains a need to provide even more accurate devices and techniques for measurement of beamlet properties in lithography systems, particularly in lithography machines comprising a large number of charged-particle beamlets that are designed to offer a high throughput.

BRIEF SUMMARY OF THE INVENTION

It is also an object of the present invention to provide for an improved lithography system with enhanced resolution performance provided with a correspondingly improved knife edge sensor;

It is hence an object of the present invention to provide for a sensor with enhanced resolution;

It is a further object of the present invention to provide for a knife edge sensor improved with respect to accuracy;

Another object of the present invention is to provide for a new method of manufacturing a knife edge sensor;

Yet another object of the present invention is to provide for a method of manufacturing a knife edge sensor of the known kind, enabling said improvements according to the preceding objects of the invention;

For this purpose, the present invention provides a charged particle beamlet lithography system for transferring a pattern to a surface of a target comprising a sensor used for determining one or more characteristics of one or more charged particle beamlets, comprising a surface element for exposure by one or a plurality of charged particles beamlets, the sensor surface element comprising a converter element for receiving charged particles and generating photons in response, the converter element comprising a surface for receiving the plurality of charged particle beamlets, the surface being provided with one or more cells for evaluating one or more individual beamlets, each cell comprising a predetermined blocking pattern of one or more charged particle blocking structures forming multiple knife edges at transitions between blocking and non-blocking regions along a predetermined beamlet scan trajectory over said portion, wherein said converter surface is covered by a light stopping metal layer permeable to said beamlets, and wherein the sensor between said light stopping layer and said blocking structures comprises a further electrically conductive layer.

In respect of the lithography system, sensor and sensor surface, it is remarked that for good performance of lithography system and sensor, the latter should be uniform over a considerable area, typically over 3 X 3 mm in above indicated contemporary systems requiring a massive multiplicity of beamlets to be sensed simultaneously. An acknowledgement underlying the present invention holds that the thickness of the light stop layer would vary over the sensor area. It was further acknowledged that the wall of the edges should be as steep as possible to allow for high resolution, or to measure sinal spot size.

In response to the assessment underlying the present improvement it was conceived to additionally use a mask in the manufacturing process of the sensor. According to this conception such mask should have a high selectivity for both the etching of the charged particle stop layer, normally a layer of very heave material such as Tungsten (W), and which is also selective as a stop layer. It was found that one material for achieving this is composed, at least comprises Chromium (Cr). An advantage of using Cr is that it can be deposited in the same way as Ti, so that it can be applied without substantial amount of additional effort or difficulty. The fabrication of the new sensor and hence the new method of manufacturing process starts with the evaporation of a light stop layer, in casu Ti, the etch stop layer, in casu Cr, and the particle stop layer, in casu W, each with suitable thickness. After patterning the KE mask on the third, in casu W layer, the a fourth, etch stop layer, in casu Cr, is evaporated, after which so called lift off is performed. The sample can be etched, once the stop layer is reached. After the etch stops, the fourth and second, in casu both Cr, is removed selectively by means of wet etching. This latter process step will expose the Ti as grown, will expose the and the W surface with virtually straight wall, i.e. allows the creation of walls at least virtually orthogonal relative to said Ti surface, and prevents the occurrence of so called foot parts at the bottom of walls as of said known sensor without the present manufacturing process, i.e. without an etch stop, or Cr layer between said light stop, e.g. Al or Ti layer, and said layer of charged particle stop structures, e.g. comprising W.

BRIEF DESCRIPTION OF THE DRAWINGS

The features and advantages of the invention will be appreciated upon reference to the following drawings, in which:

FIG. 1 schematically shows the concept of a sensor using a substrate converting charged particles into photons;

FIG. 2A schematically shows a cross-section of a converter element provided with a blocking structure;

FIG. 2B represents a graph showing the transmitted intensity as a function of position for the blocking structure of FIG. 2A;

FIG. 2C schematically shows a problem related to line edge roughness;

FIG. 2D schematically illustrates a prior art knife edge sensor layer composition;

FIGS. 3A-3H schematically show different stages of a method of manufacturing a sensor surface element;

DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

The following is a description of certain embodiments of the invention, given by way of example only and with reference to the drawings.

FIG. 1 schematically shows the operation of a sensor for determining one or more characteristics of particle beams, in particular one or more characteristics of charged particle beamlets. The sensor comprises a converter element **1** and a photon receptor **5**. The converter element is provided with a pattern comprising charged particle blocking regions **8** and charged particle transmissive regions **7**, further referred to as non-blocking regions. The converter element **1** is arranged for receiving charged particles **2** and generating photons **3** in response. The photons **3** may be directed towards the photon receptor **5** by means of an optical system **11**. The photon receptor **5** is communicatively coupled to a calculation unit, e.g. a computer **13** for determining one or more characteristics of the charged particles **2**.

The converter element **1** may take the form of a fluorescent element, for example a fluorescent screen, or a scintillating element, for example a substrate of a doped yttrium aluminum garnet (YAG) material. Hereafter, embodiments of the invention will be described in with a YAG-screen being used as converter element **1**, where the YAG-screen may be referred to as YAG **1**.

The photon receptor **5** may include any suitable light sensitive detector, such as a plurality of diodes, charged coupled device (CCD) cameras or complementary metal-oxide semiconductor (CMOS) cameras. Hereafter, the photon receptor **5** may be referred to as camera **5**.

Additionally, although embodiments of the invention may be used for any type of (charged) particles or light beams **2**, hereafter, embodiments of the invention will be discussed with reference to electrons.

In electron beamlet devices where the beamlet size is in the nanometer range, for example electron microscopes, electron beam lithography apparatus, and electron beam pattern generators, direct observation of photons created by conversion by the converter element **1** is insufficient to enable determination of characteristics such as position of an electron beamlet as the resolution is limited by the wavelength of the converter element **1**. To improve accuracy, an electron beamlet may be scanned across an electron blocking structure provided with sharp edges, further referred to as knife edges. An example of a sensor using a converter element provided with a knife edge is described in patent application US 2007/057204.

FIG. 2A schematically shows a cross-section of a YAG **1** comprising an electron beamlet receiving surface provided with an electron blocking structure. The electron blocking structure comprises electron blocking regions provided with a layer **18** capable of blocking electrons. The blocking layer **18** may be a metal layer. A suitable metal for blocking electrons is tungsten. In between the blocking regions are non-blocking regions. An electron beam **22** impinging onto a non-blocking region of the electron blocking structure actually impinges onto the surface of the YAG **1** or a coating on the surface of the YAG.

Within the portions for blocking electrons, besides the blocking layer **18** an additional layer **21** may be present. The additional layer **21** may be a metal layer, and may serve the purpose of increasing the uniformity of the blocking layer **18**. A suitable material for the additional layer **21** has a high selectivity with both wet and dry etching in relation to the first and third coated layer. One such material is chrome.

The YAG **1** may be coated with a coating layer **20**. The coating layer may be a metal layer for blocking background radiation. Suitable materials for the coating layer **20** include aluminum and titanium, in fact any material such as light metals, that is electrically conductive and that is permeable to charged particle beams on the one hand, and stopping for ambient light on the other hand within limited ranges of thickness.

As mentioned earlier, in order to determine one or more characteristics of an electron beam **22**, the electron beam **22** may be scanned over a blocking structure provided on the YAG **1** (in FIG. 2A in a direction denoted as X-direction). In response, photons generated within the YAG **1** may be detected by a camera. An exemplary result of such scanning and detection action is schematically depicted in FIG. 2B.

FIG. 2B shows a graph representing intensity of light emitted by a converter element **1** as a function of x-position of an electron beam **22** over the surface of the converter element **1**. A maximum response is observed when electron beam **22** is entirely positioned in a non-blocking region, and minimal light is generated if the electron beam **22** is positioned entirely on top of a blocking region. The crossing of a knife edge results in a steep change of light intensity.

In some embodiments, in order to provide a robust processing of measurement results, intensity levels exceeding a higher threshold value T_h are provided as high level signal values to a processor. Similarly, detected intensity levels below a lower threshold value T_l may be provided as low level signal values. The use of threshold values T_h, T_l may enable the use of digital processing.

Upon scanning an electron beam in a predetermined direction, the electron beamlet may encounter two types of situations while crossing a knife edge. In a first situation, the beamlet experiences a transition from a blocking region to a non-blocking region. In a second situation, the beamlet experiences a transition from a non-blocking region to a blocking region.

Knife edges being encountered during a transition that corresponds to the first situation may be referred to as knife edges of a first type. Similarly, knife edges being encountered during a transition that corresponds to the second situation may be referred to as knife edges of a second type. The type of knife edge is thus dependent on the scanning direction of the beamlet to be measured. If reference is made to "knife edges of similar type", this means that all the knife edges involved either relate to knife edges of the first type or relate to knife edges of the second type.

Knowledge of the knife edge pattern provided on the electron-receiving surface of the converter element surface allows for the determination of one or more characteristics of a beamlet. Characteristics that can be measured by using a sensor as described with reference to FIG. 1, and a knife edge pattern as described with reference to FIG. 2A, include beamlet position and beamlet spot size, where the spot size relates to the size of the electron beamlet on the surface of the converter element **1**.

For example, beamlet position can be measured by scanning the beamlet across the surface of the converter element in the x-direction and measuring the position at which the intensity of light emitted by a converter element changes from a maximum to a minimum value or from a minimum to a maximum value, as shown in FIG. 2B. For example, when the intensity changes from maximum to minimum value, this indicates that the beamlet is scanned over a knife edge transitioning from a non-blocking region to a blocking region in the x direction. However, there may be uncertainty as to which knife edge the beamlet is located at.

The size of the beamlet can be determined, for example, by measuring the distance between the point at which the intensity begins to decrease from a maximum value, to the point at which the intensity reaches a minimum value as the beamlet is scanned across a knife edge. This indicates the distance over which the beamlet is partly blocked and partly un-blocked. Similarly, the beamlet size can be determined by measuring the time between sensing a maximum intensity and sensing a minimum intensity as the beamlet is scanned across a knife edge, and multiplying by the scanning speed of the beamlet. These measurements can also be performed on the opposite knife edge, the beamlet moving from minimum to maximum intensity.

Note that the measurement shown in FIG. 2B, and the discussion of beamlet position and beamlet size measurements relates to a beamlet having dimensions that are smaller than the widths of the blocking and non-blocking regions involved. These dimensions and widths are preferably taken along a direction parallel to the scan direction being used.

In many applications, a single knife edge is not suitable to obtain beamlet characteristics with sufficient accuracy. In particular so-called line edge roughness (LER) of a knife edge may limit the accuracy of beamlet measurements. FIG. 2D schematically illustrates a problem related to LER. In FIG. 2D, a sensor is arranged to detect the intensity of a beamlet being moved across a knife edge **31** separating an electron blocking region **33** and an electron non-blocking region **34**. The knife edge **31** is designed to have the orientation and shape as denoted by the dotted line **32**.

If the x-position of the beamlet is detected under the assumption that it follows a trajectory A across the knife edge **31** from the blocking region **33** towards the non-blocking region **34**, while in reality the trajectory B is followed, the beamlet position in the scanning direction should be the same for both trajectories. After all, both trajectories cross the dotted line **32** at the same x-position. However, as can be readily seen in FIG. 2D, due to the line edge roughness of the knife edge **31**, the measured x-position of the beamlet for trajectory A will be different than the measured x-position for trajectory B. In this example, determining the x-position based on the crossing of single knife edge **31** provides an inaccurate result.

FIGS. 3A-3H schematically show different stages of a method of manufacturing a sensor surface element. The sensor surface element is arranged for selectively converting impinging charged particles into photons.

First, as shown in FIG. 3A, a substrate **101** is provided for supporting the sensor surface element. The substrate **101** comprises a conversion material for converting charged particles into photons. Such conversion material may be a scintillating material. In particular for applications where electrons are used as charged particles, a suitable scintillating material may be a material comprising an yttrium aluminum garnet (YAG).

Subsequently, as shown in FIG. 3B, a surface side of the substrate **101** arranged for reception of charged particles is coated with one or more metal layers. The metal layers may comprise a first metal layer **103** comprising a first metal for blocking background radiation. Such background light blocking layer enhances quality of the sensor by preventing background light from interfering with the light generated by the converter element. Generally, if present, the first metal layer **103** has a thickness within the range of about 30 to about 80 nm. Suitable materials for the first metal include titanium and aluminum, Ti being preferred as less prone to oxidizing over time and hence more conducive to maintaining lasting surface uniformity of said layer.

Additionally, the one or more metal layers may comprise a second metal layer **104** comprising a second metal. The second metal layer may serve as a stopping layer for realizing improved etching quality, for example for realizing sharper edges. A suitable material for the second metal is chrome.

Finally, the one or more metal layers comprise a third metal layer **105** comprising a third metal for blocking charged particle beamlets. A suitable material for the third metal for blocking electrons is tungsten, in fact any material such as heavy metals that is blocking to charged particles and to ambient light within reasonable, i.e. preferably lowest amount of thickness. A suitable thickness of the third metal layer **105**, in particular if it comprises tungsten, lies within the range of 50 to 500 nm. Such thickness is thick enough to sufficiently block incoming charged particles. On the other hand, such thickness has a negligible influence on effects like defocus and edge roughness.

On top of the number of metal layers **103**, **104**, **105**, a resist layer **107** is provided. As schematically shown in FIG. 3C, the resist layer **107** may be a single or alternatively a double resist layer comprising an upper layer **107a**, and a lower layer **107b** respectively.

The resist layer **107** is then patterned in correspondence to a first predetermined pattern. After patterning, the resist layer undergoes developing and etching steps in a fashion generally known in the art. The etching is performed until the third metal layer **105** is exposed. An exemplary end result of patterning, developing and etching the resist layer **107** is schematically shown in FIG. 3D.

After etching, the exposed third metal layer **105** is coated with a fourth metal layer **109**, for example by means of evaporation, as is schematically shown in FIG. 3E. The fourth metal layer **109** may serve as an etch stopping layer and may improve etching quality. The layer **109** may comprise the same metal as used in the second metal layer, for example chrome.

After deposition of the fourth metal layer **109**, the developed resist is removed by lift off such that the third metal layer **105** is exposed in accordance with a second predetermined pattern, as schematically shown in FIG. 3F. The second predetermined pattern is an inversion of the first predetermined pattern.

Subsequently, the exposed third metal layer **105** is etched in accordance with the second predetermined pattern until the second metal layer **104** is exposed. A schematic drawing of the sensor surface element at this stage of the manufacturing process is shown in FIG. 13G.

Finally, as schematically shown in FIG. 3H, the fourth metal layer **109** as well as the second layer **104** in accordance with the second predetermined pattern are removed, the latter one until the first metal layer **103** is exposed. Removal may be performed by techniques known in the art, e.g. etching, in casu Cr etching.

The invention has been described by reference to certain embodiments discussed above. It will be recognized that these embodiments are susceptible to various modifications and alternative forms well known to those of skill in the art.

Further modifications in addition to those described above may be made to the structures and techniques described herein without departing from the spirit and scope of the invention. Accordingly, although specific embodiments have been described, these are examples only and are not limiting upon the scope of the invention.

CLAUSES

1. Charged particle beamlet lithography system for transferring a pattern to a surface of a target comprising a sensor used for determining one or more characteristics of one or more charged particle beamlets, comprising a surface element for exposure by one or a plurality of charged particles beamlets, the sensor surface element comprising a converter element for receiving charged particles and generating photons in response, the converter element comprising a surface for receiving the plurality of charged particle beamlets, the surface being provided with one or more cells for evaluating one or more individual beamlets, each cell comprising a predetermined blocking pattern of one or more charged particle blocking structures forming multiple knife edges at transitions between blocking and non-blocking regions along a predetermined beamlet scan trajectory over said element surface, wherein said converter surface is covered by a light stopping metal layer permeable to said beamlets, and wherein the sensor between said light stopping layer and said blocking structures comprises a further electrically conductive layer.

2. System according to clause 1, wherein the sensor is adapted for simultaneously generating a signal in response to each of the plurality of charged particles beamlets.

3. System according to clause 1 or 2, wherein the further conductive layer is included in line or at least slightly recessed in view of a vertical projection of a blocking layer edge or as taken in top view.

4. System according to clause 1, 2 or 3, wherein the material of the further conductive layer is Chromium (Cr).

5. System according to any one of the preceding clauses, wherein the blocking structures comprise a layer of tungsten (W).

6. System according to any one of the preceding clauses, wherein the converter element comprises a scintillating material.

7. System according to the immediately preceding clause, wherein the scintillating material comprises an Yttrium Aluminum Garnet (YAG).

8. System according to any one of the preceding clauses, wherein the light blocking layer comprises Titanium.

9. System according to any of the preceding clauses, wherein the system comprises a control unit for receiving signals from a photon receptor associated with said sensor surface, and for determining a characteristic of said plurality of beamlets and or one or more characteristics of individual beamlets of said plurality of charged particle beamlets, based on said signals.

10. System according to any of the preceding clauses, further comprising

- a beamlet generator for generating a plurality of charged particle beamlets;
- a modulation system for modulating the charged particle beamlets in accordance with a pattern to be transferred;
- an electron-optical system for focusing the modulated beamlets onto the surface of said target;
- a deflecting system for deflecting said focused beamlets over the surface of either said target or a sensor for determining beamlet characteristics, replacing said target surface.

11. System according to the preceding or one but preceding clause, wherein the charged particle beamlets are electron beamlets.

12. Sensor for generating a signal in response to exposure thereof by a charged particle beam, the sensor comprising a sensor surface element as defined in any one of the preceding clauses, a photon receptor associated with said sensor surface, and generating a signal on the basis of photons generated upon exposure of said associated surface by a charged particle beamlet.

13. Sensor for generating a signal in response to exposure thereof by a charged particle beam, the sensor comprising a sensor surface element for exposure by one or a plurality of charged particles beamlets, the sensor surface element comprising a converter element for receiving charged particles and generating photons in response, the converter element comprising a surface for receiving the plurality of charged particle beamlets, the surface being provided with one or more cells for evaluating one or more individual beamlets, each cell comprising a predetermined blocking pattern of one or more charged particle blocking structures forming multiple knife edges at transitions between blocking and non-blocking regions along a predetermined beamlet scan trajectory over said portion, wherein said converter surface is covered by a light stopping metal layer permeable to said

beamlets, and wherein the sensor between said light stopping layer and said blocking structures comprises a further electrically conductive layer, the sensor further comprising a photon receptor associated with said sensor surface element, and generating a signal on the basis of photons generated upon exposure of said associated surface by a charged particle beamlets.

14. Sensor according to anyone of clause 12 and clause 13, the sensor comprising a surface element comprising:

- a photon receptor for receiving photons emitted by said converter element and forming reception information based on the photons received, and
- a control unit for receiving the reception information from the photon receptor and determining a characteristic of the plurality of charged particle beams based on the reception information.

15. Sensor surface element for a sensor and lithography system, as defined by the sensor surface features according to any of the preceding clauses.

16. Sensor surface element for use in a sensor or lithography system, for sensing a characteristic of a plurality of charged particles beamlets, the sensor surface element comprising a converter element for receiving charged particles and generating photons in response, the converter element comprising a surface for receiving the plurality of charged particle beamlets, the surface being provided with a plurality of cells for evaluating individual beamlets, each cell comprising a predetermined blocking pattern of one or more charged particle blocking structures, forming multiple knife edges at transitions between blocking and non-blocking regions along a predetermined beamlet scan trajectory over said portion, wherein said converter surface is covered by a light stopping metal layer permeable to said beamlets, and wherein the sensor between said light stopping layer and said blocking structures comprises a further electrically conductive layer.

17. Method of manufacturing a sensor surface element arranged for selectively converting impinging charged particles into photons, the method comprising:

- providing a substrate comprising a conversion material for converting charged particles into photons;

- subsequently coating the substrate with a first material layer comprising an electrically conductive layer, a second material layer comprising an etch stop material and a third material layer comprising a third material;
- providing a resist layer on top of said third layer;
- patterning, and developing the resist layer so as to form a first predetermined pattern, and etching the developed resist layer until the third material layer is exposed;
- coating the exposed third material layer with a fourth material layer comprising an etch stop material;
- lifting of the developed resist such that the third material layer is exposed in accordance with a second predetermined pattern, the second predetermined pattern being an inversion of the first predetermined pattern
- etching the third material layer in accordance with the second predetermined pattern until the second material layer is exposed;
- etching the fourth material layer as well as the second material layer in accordance with the second predetermined pattern until the first material layer is exposed.

18. The method according to clause 17, wherein said first layer is stopping for ambient light and permeable to charged particle beamlets.

19. The method according to clause 17 or 18, wherein the fourth metal layer comprises the second metal.

20. The method according to clause 19, wherein the second metal is chrome.

21. The method of any of the preceding method clauses wherein the material of the first layer comprises one of titanium (Ti) and aluminum (Al).

22. The method of any one of the preceding method clauses wherein the third layer material has a high selectivity to both of wet and dry etching in relation to the material of said first and second layer respectively.

23. The method of any one of the preceding method clauses wherein the third layer material comprises tungsten (W).

24. The method of any of the preceding method clauses, wherein the conversion material comprises a scintillating material.

25. The method of the immediately preceding clause, wherein the scintillating material comprises an Yttrium Aluminum Garnet.

CONCLUSIES

1. Een geladen deeltjes bundel systeem voor het overzetten van een patroon naar het oppervlak van een doel object, omvattende een sensor voor het bepalen van een of meer eigenschappen van een of meer geladen deeltjes bundels, omvattende een oppervlakte element voor blootstelling aan een of een veelvoud van geladen deeltjes bundels, het sensor oppervlakte element omvattende een omzet element voor het ontvangen van geladen deeltjes en het in reactie hierop genereren van fotonen, het omzet element omvattende een oppervlak voor het ontvangen van het veelvoud aan geladen deeltjes bundels, waarbij het oppervlak voorzien is van een of meerdere cellen voor het evalueren van een of meer individuele bundels, elke cel omvattende een vooraf bepaald blokkerend patroon van een of meer geladen deeltjes blokkerende structuren, vormende een veelvoud aan meskanten op overgangen tussen blokkerende en niet-blokkerende regionen langs een vooraf bepaald bundel scan traject over voornoemd oppervlak waarbij voornoemd omzet oppervlak is bedekt met een licht stoppende metaal laag doordringbaar voor voornoemde geladen deeltjes bundels, en waarbij de sensor tussen de licht stoppende laag en voornoemde blokkeringstructuren verder een elektrisch geleidende laag omvat.

2. Het systeem volgens conclusie 1, waarbij de sensor is aangepast voor het gelijktijdig genereren van een signaal in reactie op elk van het veelvoud aan geladen deeltjes bundels.

3. Het systeem volgens conclusie 1 of conclusie 2, waarbij de elektrisch geleidende laag, met betrekking tot een verticale projectie ofwel in bovenaanzicht, in lijn met of tenminste gering teruggetrokken opgenomen is ten opzichte van een blokkerende laag.

4. Het systeem volgens conclusie 1,2 of 3, waarbij het materiaal van de geleidende laag chroom (Cr) is.

5. Het systeem volgens een der voorgaande conclusies, waarbij de blokkerende structuur een laag wolfraam (W) omvat.

6. Het systeem volgens een der voorgaande conclusies, waarbij het materiaal van het omzet element scintillerend materiaal is.

7. Systeem volgens de voorgaande conclusie, waarbij het scintillerend materiaal Yttrium Aluminium Granaat (YAG) omvat.

8. Het systeem volgens een der voorgaande conclusies, waarbij de licht stoppende laag titanium (Ti) omvat.

9. Systeem volgens een der voorgaande conclusies, waarbij het systeem een controle eenheid omvat voor het ontvangen van signalen van een foton receptor geassocieerd met voornoemd sensor oppervlak, en voor het bepalen van een eigenschap van voornoemde veelvoud aan bundels en een of meer eigenschappen van individuele bundels van de geladen deeltjes bundels, gebaseerd op voornoemde signalen.

10. Systeem volgens een der voorgaande conclusies, verder omvattende:

- een bundel generator voor het genereren van een veelvoud aan geladen deeltjes bundels;
- een modulatie systeem voor het moduleren van de geladen deeltjes bundels in overeenstemming met het over te zetten patroon;
- een elektro-optisch systeem voor het focusseren van de gemoduleerde bundels op het oppervlak van voornoemd doel object;
- een deflectie systeem voor het deflecteren van voornoemde gefocusseerde bundels over het oppervlak van ofwel voornoemd doel object ofwel een sensor voor het bepalen van de bundel eigenschappen, waarbij voornoemde sensor voornoemd doel object oppervlak vervangt.

11. Systeem volgens de voorgaande of op een na voorgaande conclusie, waarbij de geladen deeltjes bundels, elektronenbundels zijn.

12. Sensor voor het genereren van een signaal in respons tot blootstelling aan een geladen deeltjes bundel, de sensor omvattende een oppervlakte element zoals gedefinieerd in een der voorgaande conclusies, een foton ontvanger geassocieerd met voornoemd sensor oppervlak welke ontvanger een signaal genereert op basis van de gegenereerde fotonen door blootstelling van voornoemd oppervlak aan een geladen deeltjes bundel.

13. Sensor voor het genereren van een signaal in respons tot de blootstelling van voornoemde sensor aan een geladen deeltjes bundel, de sensor omvattende een sensor oppervlakte element voor blootstelling aan een of meerdere geladen deeltjes bundels, het sensor oppervlakte element omvattende een omzet element voor het ontvangen van geladen deeltjes en het genereren van fotonen in respons hierop, het omzet element omvattende een oppervlak voor het ontvangen van een veelvoud van geladen deeltjes

bundels, het oppervlak voorzien van een of meer cellen voor het evalueren van een of meer individuele bundels, elke cel omvattende een vooraf bepaald blokkerend patroon van een of meer geladen deeltjes blokkerende structuren vormende een veelvoud aan meskanten op transities tussen blokkerende en niet blokkerende regionen langs een vooraf bepaald bundel scan traject over voornoemd deel, waarbij voornoemd omzet oppervlak is bedekt met een licht stoppende metaal laag doordringbaar voor voornoemde geladen deeltjes bundels en waarbij de sensor tussen voornoemde licht stoppende laag en voornoemde blokkerende structuren verder een elektrisch geleidende laag omvat, de sensor verder omvattende een fotonen ontvanger geassocieerd met voornoemd sensor oppervlakte element, en genererende een signaal op basis van de fotonen gegenereerd door blootstelling van voornoemd geassocieerd oppervlak aan geladen deeltjes bundels.

14. Sensor volgens conclusie 12 of conclusie 13, de sensor omvattende een oppervlakte element, omvattende:

- een fotonen ontvanger voor het ontvangen van fotonen uitgezonden door voornoemd omzet element en vormende ontvangst informatie gebaseerd op de ontvangen fotonen

- een controle eenheid voor het ontvangen van de ontvangst informatie van de fotonen ontvanger en voor het bepalen van de karakteristieken van de veelvoud aan geladen deeltjes bundels gebaseerd op de ontvangst informatie.

15. Sensor oppervlakte element voor een sensor en lithografie systeem, zoals gedefinieerd door de oppervlakte kenmerken volgens een der voorgaande conclusies.

16. Sensor oppervlakte element voor gebruik in een sensor of lithografie systeem, voor het meten van een karakteristiek van een veelvoud van geladen deeltjes bundels, het sensor oppervlakte element omvattende een omzet element voor het ontvangen van geladen deeltjes welk daarop als respons fotonen genereert, het omzet element omvattende een oppervlak voor het ontvangen van een veelvoud aan geladen deeltjes bundels, het oppervlak voorzien van een veelvoud aan cellen voor het evalueren van individuele bundels, elke cel omvattende een vooraf bepaald blokkerend patroon van een of meer geladen deeltje blokkerende structuren, vormende een veelvoud aan meskanten op de transities tussen de blokkerende en niet blokkerende regionen langs een vooraf bepaald bundel scan traject over voornoemd deel, waarin voornoemd omzet oppervlak is bedekt met een licht stoppende metaal laag doordringbaar voor voornoemde geladen deeltjes

bundels en waarbij de sensor tussen de licht stoppende laag en voornoemde blokkerende structuren verder een elektrisch geleidende laag omvat.

17. Methode voor het fabriceren van een sensor oppervlakte element opgenomen voor het selectief omzetten van invallende geladen deeltjes in fotonen, deze methode omvattende:

- het voorzien in een substraat omvattende een omzet materiaal voor het omzetten van geladen deeltjes in fotonen;
- het vervolgens bedekken van het substraat met een eerste materiaal laag omvattende een elektrisch geleidende laag en een tweede materiaal laag omvattende een ets stop materiaal en een derde materiaal laag omvattende een derde materiaal;
- voorzien van een gevoelige laag bovenop voornoemde derde laag;
- voorzien van een patroon, en het ontwikkelen van de gevoelige laag om een eerste vooraf bepaald patroon te vormen, en etsen van de ontwikkelde gevoelige laag totdat de derde materiaal laag is blootgesteld;
- het bedekken van de blootgestelde derde metaal laag met een vierde materiaal laag omvattende een ets stop materiaal;
- het afhalen van de ontwikkelde resist zodat de derde materiaal laag is blootgesteld in overeenstemming met een tweede vooraf bepaald patroon, het tweede vooraf bepaalde patroon zijnde een inversie van het eerste vooraf bepaalde patroon;
- het etsen van de derde materiaal laag in overeenstemming met het tweede vooraf bepaalde patroon totdat de tweede materiaal laag is blootgesteld;
- het etsen van de vierde materiaal laag alsmede van de tweede materiaal laag in overeenstemming met het tweede vooraf bepaalde patroon totdat de eerste materiaal laag is blootgesteld.

18. De methode volgens conclusie 17, waarbij de eerste laag omgevingslicht tegenhoud en doordringbaar is voor geladen deeltjes bundels.

19. De methode volgens conclusie 17 of 18, waarbij de vierde materiaal laag een tweede metaal omvat.

20. De methode volgens conclusie 19, waarbij het tweede metaal chroom is.

21. De methode volgens enige van de vorige methode conclusies waarbij het materiaal van de eerste laag titanium (Ti) of aluminium (Al) omvat.

22. De methode volgens enige van de vorige methode conclusies, waarbij het derde laag materiaal een hoge selectiviteit voor zowel droog als nat etsen heeft ten opzichte van het materiaal van respectievelijk de eerste dan wel tweede laag.

23. De methode volgens enige van de vorige methode conclusies, waarbij de derde laag materiaal wolfraam (W) omvat.

24. De methode volgens enige van de vorige methode conclusies, warbij het omzet materiaal een scintillator materiaal omvat.

25. De methode volgens de direct hiervoor genoemde conclusie, waarbij het scintillator materiaal Yttrium Aluminium Granaat (YAG) omvat.

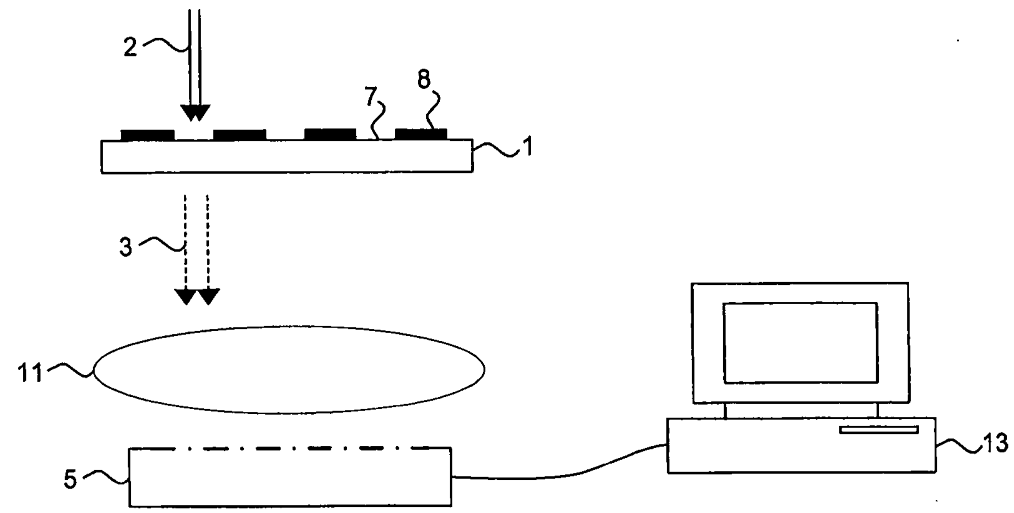

FIG. 1

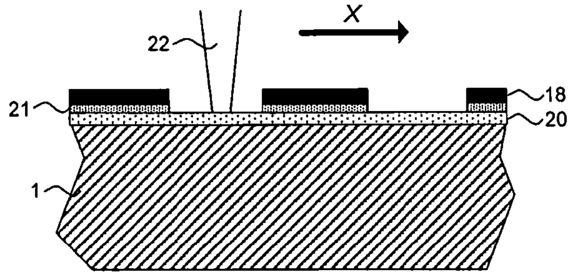

FIG. 2A

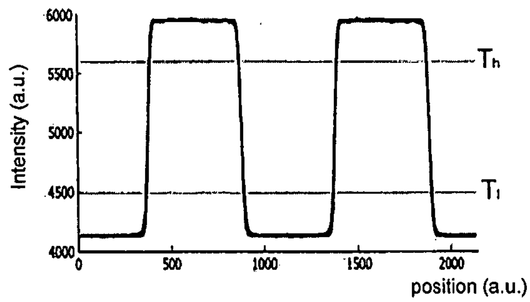

FIG. 2B

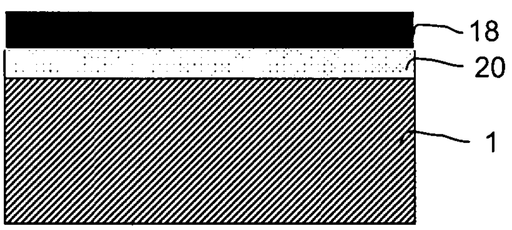

FIG. 2C

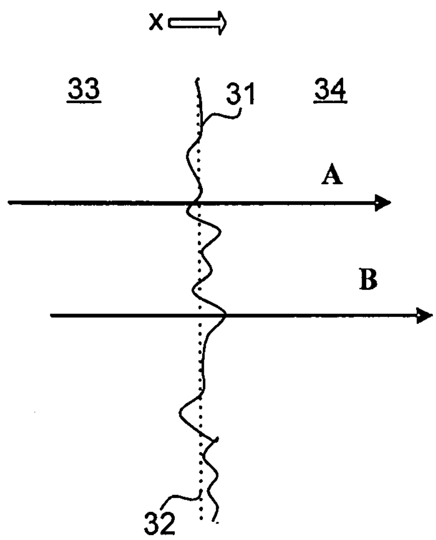

FIG. 2D

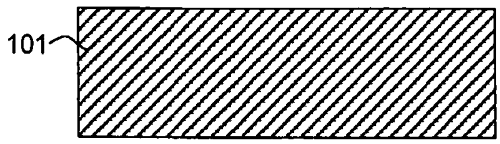

FIG. 3A

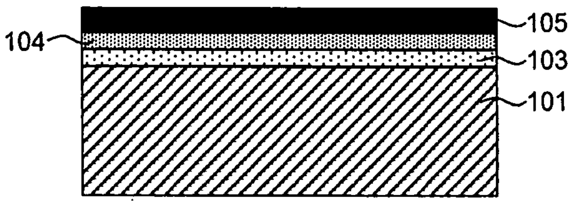

FIG. 3B

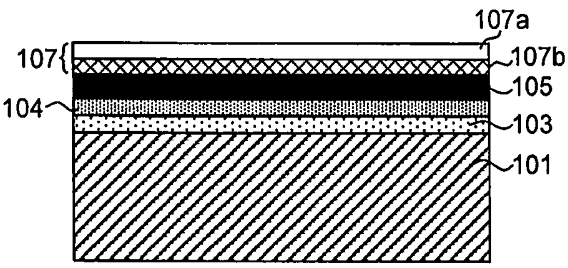

FIG. 3C

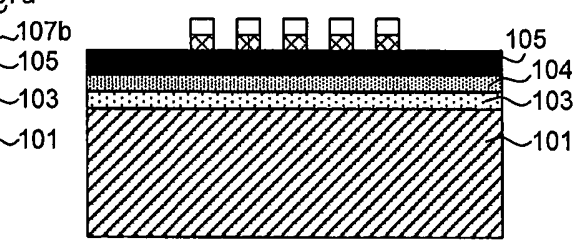

FIG. 3D

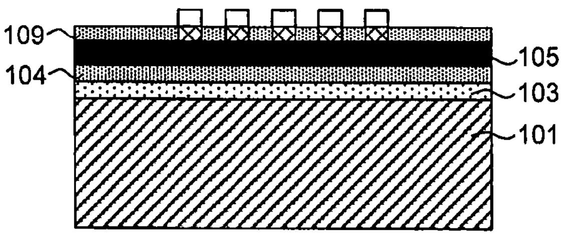

FIG. 3E

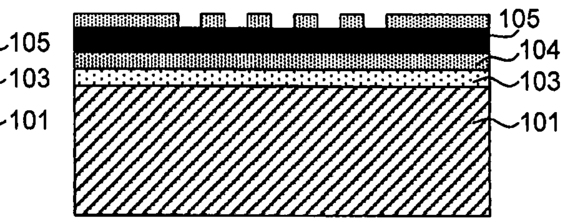

FIG. 3F

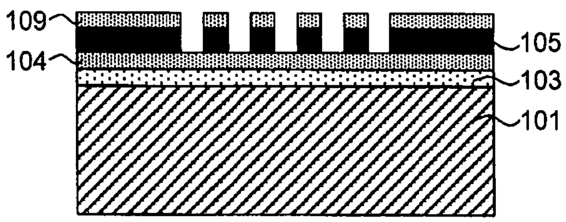

FIG. 3G

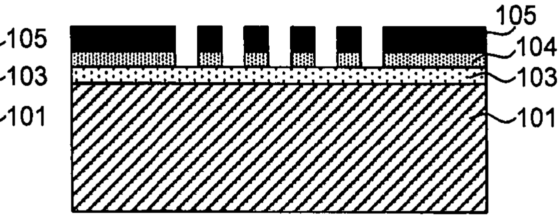

FIG. 3H

1037820

OCTROOICENTRUM NEDERLAND

OCTROOIAANVRAAG NR.:
NO 137248
NL 1037820

ONDERZOEKSRAPPORT

BETREFFENDE HET RESULTAAT VAN HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK

RELEVANTE LITERATUUR

Categorie[1]	Literatuur met, voor zover nodig, aanduiding van speciaal van belang zijnde tekstgedeelten of figuren.	Van belang voor conclusie(s) nr:	Classificatie (IPC)
A,D	US 2007/057204 A1 (KRUIT PIETER [NL] ET AL) 15 maart 2007 (2007-03-15) * alineas [0012] - [0016], [0047], [0048] * -----	1-25	INV. H01J37/244 H01J37/317 H01J37/304
A	KADEL K ET AL: "X-ray masks with tungsten absorbers for use in the LIGA process" MICROELECTRONIC ENGINEERING, deel 21, nr. 1-4, 1 april 1993 (1993-04-01), bladzijden 123-126, XP024437035 ELSEVIER PUBLISHERS BV., AMSTERDAM, NL ISSN: 0167-9317 DOI: 10.1016/0167-9317(93)90041-3 [gevonden op 1993-04-01] * bladzijde 2 * -----	1-25	
A	PANG M ET AL: "PAPER L7.2 :Thin film fracture during nanoindentation of hard film-soft substrate systems" MATERIALS RESEARCH SOCIETY SYMPOSIUM - PROCEEDINGS 2002, deel 695, 26 november 2001 (2001-11-26), bladzijden 1-6, XP002609220 MATERIALS RESEARCH SOCIETY US * het gehele document * -----	1-25	**Onderzochte gebieden van de techniek** H01J

Indien gewijzigde conclusies zijn ingediend, heeft dit rapport betrekking op de conclusies ingediend op:

Plaats van onderzoek:	Datum waarop het onderzoek werd voltooid:	Bevoegd ambtenaar:
München	12 November 2010	Oestreich, Sebastian

[1] CATEGORIE VAN DE VERMELDE LITERATUUR

X: de conclusie wordt als niet nieuw of niet inventief beschouwd ten opzichte van deze literatuur
Y: de conclusie wordt als niet inventief beschouwd ten opzichte van de combinatie van deze literatuur met andere geciteerde literatuur van dezelfde categorie, waarbij de combinatie voor de vakman voor de hand liggend wordt geacht
A: niet tot de categorie X of Y behorende literatuur die de stand van de techniek beschrijft
O: niet–schriftelijke stand van de techniek
P: tussen de voorrangsdatum en de indieningsdatum gepubliceerde literatuur

T: na de indieningsdatum of de voorrangsdatum gepubliceerde literatuur die niet bezwarend is voor de octrooiaanvrage, maar wordt vermeld ter verheldering van de theorie of het principe dat ten grondslag ligt aan de uitvinding
E: eerdere octrooi(aanvrage), gepubliceerd op of na de indieningsdatum, waarin dezelfde uitvinding wordt beschreven
D: in de octrooiaanvrage vermeld
L: om andere redenen vermelde literatuur
&: lid van dezelfde octrooifamilie of overeenkomstige octrooipublicatie

AANHANGSEL BEHORENDE BIJ HET RAPPORT BETREFFENDE HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK, UITGEVOERD IN DE OCTROOIAANVRAGE NR.

NO 137248
NL 1037820

Het aanhangsel bevat een opgave van elders gepubliceerde octrooiaanvragen of octrooien (zogenaamde leden van dezelfde octrooifamilie), die overeenkomen met octrooischriften genoemd in het rapport.
De opgave is samengesteld aan de hand van gegevens uit het computerbestand van het Europees Octrooibureau per
De juistheid en volledigheid van deze opgave wordt noch door het Europees Octrooibureau, noch door het Bureau voor de Industriële eigendom gegarandeerd; de gegevens worden verstrekt voor informatiedoeleinden.

12-11-2010

In het rapport genoemd octrooigeschrift	Datum van publicatie	Overeenkomend(e) geschrift(en)	Datum van publicatie
US 2007057204 A1	15-03-2007	GEEN	

EPO FORM P0466

Algemene informatie over dit aanhangsel is gepubliceerd in de 'Official Journal' van het Europees Octrooibureau nr 12/82 blz 448 ev

OCTROOICENTRUM NEDERLAND

SCHRIFTELIJKE OPINIE

DOSSIER NUMMER	INDIENINGSDATUM	VOORRANGSDATUM	AANVRAAGNUMMER
NO137248	22.03.2010		NL1037820

CLASSIFICATIE INV. H01J37/244 H01J37/317 H01J37/304
AANVRAGER Mapper Lithography IP B.V.

Deze schriftelijke opinie bevat een toelichting op de volgende onderdelen:

- ☒ Onderdeel I Basis van de schriftelijke opinie
- ☐ Onderdeel II Voorrang
- ☐ Onderdeel III Vaststelling nieuwheid, inventiviteit en industriële toepasbaarheid niet mogelijk
- ☐ Onderdeel IV De aanvraag heeft betrekking op meer dan één uitvinding
- ☒ Onderdeel V Gemotiveerde verklaring ten aanzien van nieuwheid, inventiviteit en industriële toepasbaarheid
- ☐ Onderdeel VI Andere geciteerde documenten
- ☐ Onderdeel VII Overige gebreken
- ☒ Onderdeel VIII Overige opmerkingen

	DE BEVOEGDE AMBTENAAR
	Oestreich, Sebastian

Aanvraag nr.:

SCHRIFTELIJKE OPINIE

NL1037820

Onderdeel I Basis van de Schriftelijke Opinie

1. Deze schriftelijke opinie is opgesteld op basis van de meest recente conclusies ingediend voor aanvang van het onderzoek.

2. Met betrekking tot **nucleotide en/of aminozuur sequenties** die genoemd worden in de aanvraag en relevant zijn voor de uitvinding zoals beschreven in de conclusies, is dit onderzoek gedaan op basis van:

   a. type materiaal:

   - ☐ sequentie opsomming
   - ☐ tabel met betrekking tot de sequentie lijst

   b. vorm van het materiaal:

   - ☐ op papier
   - ☐ in elektronische vorm

   c. moment van indiening/aanlevering:

   - ☐ opgenomen in de aanvraag zoals ingediend
   - ☐ samen met de aanvraag elektronisch ingediend
   - ☐ later aangeleverd voor het onderzoek

3. ☐ In geval er meer dan één versie of kopie van een sequentie opsomming of tabel met betrekking op een sequentie is ingediend of aangeleverd, zijn de benodigde verklaringen ingediend dat de informatie in de latere of additionele kopieën identiek is aan de aanvraag zoals ingediend of niet meer informatie bevatten dan de aanvraag zoals oorspronkelijk werd ingediend.

4. Overige opmerkingen:

Aanvraag nr.:

SCHRIFTELIJKE OPINIE

NL1037820

Onderdeel V Gemotiveerde verklaring ten aanzien van nieuwheid, inventiviteit en industriële toepasbaarheid

1. Verklaring

Nieuwheid	Ja:	Conclusies 1-25
	Nee:	Conclusies
Inventiviteit	Ja:	Conclusies 1-25
	Nee:	Conclusies
Industriële toepasbaarheid	Ja:	Conclusies 1-25
	Nee:	Conclusies

2. Citaties en toelichting:

Zie aparte bladzijde

Onderdeel VIII Overige opmerkingen

De volgende opmerkingen met betrekking tot de duidelijkheid van de conclusies, beschrijving, en figuren, of met betrekking tot de vraag of de conclusies nawerkbaar zijn, worden gemaakt:

Zie aparte bladzijde

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

D1 US 2007/057204 A1 (KRUIT PIETER [NL] ET AL) 15 maart 2007 (2007-03-15)

D2 KADEL K ET AL: "X-ray masks with tungsten absorbers for use in the LIGA process",
MICROELECTRONIC ENGINEERING, ELSEVIER PUBLISHERS BV., AMSTERDAM, NL,
deel 21, nr. 1-4, 1 april 1993 (1993-04-01), bladzijden 123-126,
XP024437035,
ISSN: 0167-9317, DOI: DOI:10.1016/0167-9317(93)90041-3
[gevonden op 1993-04-01]

1 The claim with the broadest scope is claim 16, claiming a sensor surface. Claims 13 and 1, both drafted as independent apparatus claims contain all technical features of claim 16, and are thus *de facto* dependent claims.

2 The closest prior art is document D1, as mentioned by the applicant in the description.

2.1 The only difference of independent claim 16, and, as well claims 13 and 1, is that between the blocking structures and the light stopping layer, an additional layer is present, which is electrically conductive.

2.2 With regard to the disclosure of document D1, this solves the technical problem of improving the accuracy and the production process of the nanostructured Tungsten structures which are on an Aluminum film of 30 nm to 80 nm thickness (see page 5, column 1, last 3 lines).

2.3 Document D1 describes the materials and structures required, it is however silent as to the manufacture of the sensor. The person skilled in the art of e-beam technology would therefore consult a person skilled in the art of nano-patterned thin films.

2.4 To this person skilled in the art, it is known that deposition and structuring of these kind of films and features is a highly non trivial task. In the art of patterned thin films, it is common to use additional layers between the material layers required, these additional layers serve for example as etch stop, or as adhesion layer, or may result in less mechanical stress and thus higher precision.

2.5 From the presently available prior art, it is not clearly derivable, that the person skilled in the art will expect to encounter a problem when attempting to coat and structure Tungsten on an aluminum layer. Document D2, page 124, 3rd paragraph mentions potential problems in sputtering Tungsten, but proposes to solve these by selecting appropriate deposition parameters. Deposition of Tungsten on Aluminum is not fundamentally impossible, and has been reported in the prior art. Furthermore, when encountering deposition or patterning problems, the use of an additional layer which is electrically conductive is only one solution out of several possible solutions, from which the person skilled in the art can choose, such as changing the deposition method or parameters of the or structuring process, using another blocking layer material than Tungsten.

2.6 As none of the presently available prior art gives a guidance to the person skilled in the art, that an additional layer which is electrically conductive could have advantages over the other possible solutions, the selection of this solution is not rendered obvious to the person skilled in the art.

3 Independent method claim 17 defines the manufacture of a sensor, the result of the method steps is similar to the subject matter claimed in claim 16, and thus novel.

Re Item VIII

Certain observations on the application

3.1 However, it appears that in claim 17, the function of the layers is not sufficiently defined to solve the technical problem "selectively converting impinging charged particles into photons". In order to solve this technical problem, it is mandatory, that the first material layer is the light stopping layer (as defined in dependent claim 18) and the third material is the blocking layer. Without these features present in the claim, it lacks clarity.